European Commission

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Potentially toxic elements in European soils mapped by researchers

A new study has mapped levels of chemical elements found in European agricultural soils. In most places, unusually high concentrations are linked to geology, such as high levels of arsenic in the Massif Central in France. Human activity is to blame in some small areas, for example high concentrations of mercury were found near London and Paris. Abnormal concentrations, both too low and too high, could pose an environmental risk. This new data can be used in conjunction with the REACH Regulation[1] and can help identify areas where action may be needed in relation to toxic elements in the environment.

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Source: Reimann, C., Fabian, K., Birke, M. *et al*., 2017. GEMAS: Establishing geochemical background and threshold for 53 chemical elements in European agricultural soil. *Applied Geochemistry*. In press. DOI: 10.1016/j.apgeochem.2017.01.021

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The GEMAS (geochemical mapping of agricultural soil) project was set up to deliver good quality and comparable data on levels of metals on agricultural and grazing land soil. As part of this large-scale study, soil samples were taken from regularly ploughed fields in 33 European countries and were analysed for 53 elements. These included 28 potentially toxic elements (PTEs), such as arsenic, mercury and chromium, plus eight emerging 'high-tech' critical elements (HTCEs). Based on this work, researchers established low, normal and high element concentrations in European soils. The study is the first to establish background levels of HTCEs in Europe, which include the battery component lithium, several of the so-called rare earth elements (e.g. lanthanum and cerium) and thallium, also used in the electronics industry but historically as a rat poison and insecticide.

Significant differences were observed between levels of elements in northern and southern European soils. Northern European soils were formed following the last glacial period, about 6 000–8 000 years ago, while southern Europe has much older soils. This means that different levels of elements are normal in each region, due to a different weathering history. These geochemical background values should provide the baseline for highlighting anomalies.

Researchers compared their findings to existing soil guideline values for the effects of these elements as defined by individual Member State authorities[2]. These levels can be used as screening values for risk assessment (conservative level below which no adverse effects are expected to occur) or as clean-up concentrations (intervention limit for a certain land use). The values can depend on the ecotoxicological effects of the element, but also on the intended land use or the potential for groundwater contamination. Safe levels are site-specific, as elements may be more toxic in some types of soil. It is worthy of note that, though toxic concentrations are defined for some elements, element deficiency is not considered by the environmental and health authorities. For several trace elements, including cobalt, copper, selenium and zinc, deficiency is a much more serious problem at the European scale than toxicity, as it leads to illness in and less than optimal productivity of animals and plants[3].

In the majority of samples showing high concentrations of elements, the origin appears to be natural, linked to unusual rock types, mineral deposits, climatic effects or vegetation. For example, high levels of molybdenum, which can cause illness in sheep and other animals, occur naturally in parts of Scandinavia and Croatia.

In some areas, high concentrations are likely due to human activity such as urban development, industrial activities, mining and agriculture. For example, elevated levels of lead, silver and mercury were found near London and Paris. In vineyards in southern Europe, where copper sulphate has long been used as a fungicide, high levels of copper were detected, suggesting long-term soil pollution. Significant but local-scale anomalies were also recorded near coal-fired power plants and metal industry.

Continued on next page.

1. Regulation (EC) No 1907/2006 of the European Parliament and of the Council on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH): https://echa.europa.eu/regulations/reach

2. Given in Carlon, C. (Ed.) (2007). Derivation methods of soil screening values in Europe. *A review and evaluation of national procedures towards harmonization*. European Commission, Joint Research Centre, Ispra, EUR 22805-EN, 306 pp.

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Although the map identifies areas with high concentrations of elements, taken alone, it does not establish the cause. Neither does the map indicate risks to human or environmental health. Expert knowledge is needed to identify the source of high levels and toxicity (or deficiency) of the elements. Although the GEMAS data is useful for indicating normal levels of elements at a European scale, collecting data locally is still needed to detect, outline and monitor contamination near any given source.

Safe thresholds are not known for many of the elements observed. Sufficient information on toxicity is only available for 14 of the elements studied, but there is currently only enough information on half of these for allowing a site-specific risk assessment.

The maps can be used to highlight places where further research is needed. The researchers recommend further sampling around major cities and known sources of contamination, such as industrial activity and power plants. The results can also be used to identify areas where soils are deficient in particular trace elements, such as cobalt, copper, selenium and zinc, which can be problematic for agriculture. In terms of aerial extent, deficiency appears to be a larger problem than toxicity at the European scale. Areas displaying low natural concentrations of elements may also be useful for monitoring diffuse pollution at the European scale.

3. Reimann, C. *et al.*, 2014. Chemistry of Europe's Agricultural Soils, *Part A: Methodology and Interpretation of the GEMAS Data Set*, Geologisches Jahrbuch Reihe B, Band B 102. Schweizerbart Science Publishers, Stuttgart: 523.